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A MORPHOLOGICAL STUDY OF CICER ARIETINUM

THEO. HOLM

(WITH PLATES XLII–XLIV)

Cicer arietinum has an interesting history; the generic name was proposed by PLINY, the specific by DODONAEUS, and both were accepted by LINNAEUS. Of the seven known species of the genus, *C. arietinum* is the only one of economic importance. It has been cultivated for many years, and at present it is not known in its wild state. According to DE CANDOLLE[1] it was evidently introduced from the Orient, and this writer has given an interesting account of its history. At the time of HOMER the plant was cultivated by the Greeks under the name "erebinthos"; by DIOSCORIDES it was called "krios," on account of the seed resembling somewhat the head of a ram; the Romans called it "cicer," from which the names "chiche" (Italy) and "pois chiche" (France) are derived; the name "kikere" is used by the Albanians. Although extensively cultivated in Egypt since the beginning of the Christian era, it does not seem to have been known to the ancient Egyptians. The meaning of the names used in Spain ("garbanzo" or "garbantzua") is uncertain, being neither Arabian nor Latin. In Sanscrit it is called "chennuka," and according to BRETSCHNEIDER the plant was cultivated in China in the fourteenth century under names indicating its introduction from the west. In Greece the dried seeds are salted and roasted, and are known as "stragalia" according to HELDREICH.[2] In our western states the seeds are used for coffee, hence the name "coffee-pea." For several years I have grown the plant in my garden at Brookland, D.C. Although it is a member of the Vicieae, it shows a very peculiar habit, and the structure is interesting in several respects. No mention of this plant is made by SOLEREDER in his comprehensive work *Systematische Anatomie der Dicotyledonen.*

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[1] DE CANDOLLE, ALPHONSE, Origine des plantes cultivées. Paris. 1886.

[2] HELDREICH, TH., Die Nutzpflanzen Griechenlands. Athens. 1862.

C. arietinum is an annual, branching from the base, the several stems erect, angular or winged, densely glandular-pubescent, as are also the leaves; the primary root is quite strong, and the lateral roots bear tubercles. The leaves are odd-pinnate with obovate, dentate leaflets (fig. 4), and the stipules are incised (fig. 6). The solitary flowers (figs. 4, 5) are white, with the wings free, and they are borne on axillary peduncles, strongly reflexed; the two prophylla are very distinct. The sessile ovary contains one or two ovules, and the filiform style is incurved. The pod is relatively large (fig. 6), ovoid to oblong, turgid, 2-valved; the seeds (fig. 7) are subglobose with the radicula almost straight. As stated, the plant is glandular-pubescent, and the hairs are clavate and pluricellular (fig. 8). They contain free oxalic acid, according to VAN TIEGHEM.[3]

Seedling

So far, no description has been given of the seedling stage of this plant. The seeds require only a few days (less than a week) to germinate; a young seedling is shown in fig. 1. The primary root (*R*) is quite long, vertical, and branches freely. There is no hypocotyl, and the cotyledons (*Cot*) remain subterranean, each with an axillary bud. The plumule develops an erect shoot, the first leaves of which are merely stipules. Fig. 2 illustrates an older seedling with the primary root still longer, and with the cotyledonary buds having developed into small shoots (fig. 3). The primary shoot now represents an erect stem with typical foliage, and several axillary branches.

It is characteristic of the seedling stage, therefore, that the cotyledons remain underground, subtending axillary buds; that the epicotyl (*Ep*) is erect and stretched; and that already the first stem leaves subtend branches. The glandular pubescence appears at the seedling stage, but is not shown in the figure, since the hairs cover the stem and leaves completely, and drawn in ink they would make the figures completely black.

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[3] VAN TIEGHEM, PH., Traité de Botanique. Paris. 1884 (p. 542).

Internal structure of vegetative organs

ROOT SYSTEM

The roots are neither contractile nor developed as storage roots; they are simply nutritive and, although the plant is an annual, they increase quite considerably in thickness. This increase takes place by means of the activity of the pericambium, developing cork and a secondary cortex, beside by the development of cambial strata inside the stele, in the manner typical of dicotyledons. When fully matured the roots are very strong, owing to the abundance of stereïds outside the primary as well as outside the secondary leptome, and in the secondary hadrome. The primary structure may be studied from the apical portion of the primary root of the seedling. The epidermis is hairy, but there is no exodermis, and the cortex represents a compact parenchyma of about ten layers without deposits of starch. The endodermis is thin-walled, with Casparyan spots plainly visible. The pericambium consists of a single continuous stratum, but is separated from the stele proper by a layer of thin-walled parenchyma. Inside this parenchyma are four strands of stereome with leptome on the sides and on the inner face, beside four rays of hadrome, a small pith occupying the center of the stele. With regard to the hadrome, the protohadrome vessels are annular and reticulated, mostly two side by side, and much narrower than the inner, which vary from reticulated to porous. At this stage there are no signs of cell division in the pericambium, but narrow arches of cambial strata appear between the leptome and hadrome, and none outside the protohadrome vessels. The primary root is thus tetrarch, and the increase in thickness commences by the development of cambium between the leptome and hadrome.

Examining this same root in its older portion near the base, the following structure may be seen. Fig. 9 shows a diagram of the stele and part of the peripheral tissues, of which epidermis, cortex, and endodermis exhibit the same structure as described. Concerning the pericambium there is now a slight indication of increase, demonstrated by a tangential division (but only one) in each cell. The stereome is now more thick-walled (fig. 10, *St*), and there are many layers of cambium on the inner face of the leptome, also outside the protohadrome vessels, giving rise to several strata of thin-walled parenchyma. This parenchyma formed outside the four strands of hadrome becomes the first medullary rays (fig. 11, *M*). This more advanced stage is readily seen in fig. 9, where the cambial strata (*Camb*) are very conspicuous, beside the commencement of the formation of the four medullary rays outside the vessels. The pith remains unchanged, without becoming sclerotic, and contains no deposits of starch. A corresponding structure occurs in the lateral roots, borne on the primary, but the cambium is not so abundant. If we examine the primary root of a mature fruiting specimen, we observe the structure as shown in fig. 11. All the peripheral tissues from epidermis to endodermis inclusive are lost, but replaced by several strata of thin-walled, homogeneous cork (*Co*), and a secondary cortex (*C*) in which the four stereomatic strands are yet distinct. The cork and the secondary cortex are the products of the cell division within the pericambium. Furthermore, the deep medullary rays may be seen, only two of which have been drawn, and these (*M*) proceed from the old hadrome rays (*PH*), where they were formed originally. Secondary medullary rays are also developed. They commence within the secondary hadrome, and are shorter and much narrower than the primary. The stele is now much broader, and contains secondary stereome (fig. 12, *St*) as cells scattered outside the leptome, also among the secondary vessels (fig. 14, *St*). On the other hand, the central portion of the stele, with the four rays of hadrome and the pith, are unchanged, while the primary leptome has become absorbed completely. These secondary formations within the stele, that is, the medullary rays, the stereome, the secondary leptome (*L*), and hadrome (*H*), are all products of the cambium (fig. 9).

Characteristics of the roots of *Cicer*, therefore, are the abundance of stereids; also, that the increase in thickness commences within the stele proper and not in the pericambium. The fact that a cambium becomes developed as a circular band between the secondary leptome and hadrome (fig. 11, *Camb*) shows that further increase in thickness is secured in exactly the same manner as in the collateral mestome strands of a dicotyledonous stem.

STEM

The stems are angular to narrowly winged, densely covered with glandular (fig. 8), long, unicellular, and pointed hairs; the glandular hairs contain free oxalic acid, according to VAN TIEGHEM. The stem structure in general is quite firm, owing to the presence of hypodermal collenchyma and pericyclic stereome. The cuticle is thick, longitudinally wrinkled, and the outer cell wall of epidermis moderately thickened (figs. 16, 17, *Ep*). Corresponding with the angles or wings are hypodermal strands of thick-walled collenchyma (fig. 17, *Coll*), and the cortical parenchyma is compact, about three layers, filled with chlorophyll. There is no endodermis, but a distinct continuous pericycle, which forms arches of stereome, but is only distinct in the older portions of the stem. In young internodes (fig. 15) the pericycle is so thin-walled that it is barely distinguishable. There are about nine primary mestome strands, which are collateral, and separated from each other by meristematic strata in young internodes.

In this meristem secondary formations arise by means of an interfascicular cambium (fig. 16, *Camb*), which begins from the sides of the mestome strands. As shown in fig. 16, a small strand of leptome (*L*) is the first product within this meristem, and later on the cambium continues to develop secondary hadrome, that is, porous tracheids and libriform (fig. 18, *H*). The pith is thin-walled, and not starch bearing, but large spheric crystals were observed, the material having been preserved in alcohol. Similar crystals also occur in the cortex of the old internodes. While the structure of a young internode shows no secondary formations, in the mature stem a compact stele is found in which thick-walled libriform is very conspicuous, developed from the interfascicular cambium.

Finally may be mentioned that the epicotyl of the young seedling is glabrous, with a smooth cuticle, but without collenchyma. The cortex is very thick, about twenty layers, and an endodermis is developed outside twelve arches of pericyclic stereome, corresponding with twelve collateral mestome strands. No secondary formations occur at this stage.

Characteristic of the stem structure of *Cicer*, therefore, is the presence of endodermis in the epicotyl, and its absence from the internodes above; the glandular hairs, very seldom met with in this family; the presence of interfascicular cambium; and the spheric crystals in the cortex and pith.

LEAF

The leaf structure is not exactly bifacial, since the stomata are distributed over both faces, and equally abundant; but the chlorenchyma shows both palisade and pneumatic tissue. Hairs like those of the stem abound on both faces of the blade, and the cuticle is wrinkled above and below the stronger veins; otherwise it is thin and smooth. The epidermis is slightly thick-walled above and below the midrib, and the lateral walls are undulate on the dorsal side (fig. 19), but almost straight on the ventral side. The stomata (fig. 19) have no subsidiary cells; they are free, and raised a little, with a wide shallow air chamber. The chlorenchyma covers both faces of the leaf, and consists of a ventral palisade tissue of three layers (fig. 13, *P*), and of a pneumatic tissue of about five strata (fig. 13, P^+). There is neither collenchyma nor water storage tissue, and the veins are completely imbedded in the chlorenchyma. Around the midrib and the strong secondary veins are parenchyma sheaths, each cell of which contains a large rhombic crystal of calcium oxalate. Moreover, the midrib has a little pericyclic stereome on the leptome side, and consists of a single collateral mestome strand, with leptome, cambium, and a few vessels.

Characteristic of the leaf structure, therefore, is the distribution of the stomata over both faces of the blade; the dense chlorenchyma; the poor development of mechanical tissues; and the crystal bearing parenchyma-sheath. The internal structure of *C. arietinum* thus resembles that of a xerophilous plant among the Papilionaceae, especially when we add the profuse development of hairs, pointed, clavate, and glandular. The species evidently originated in a country with a warm and dry climate, and it has been suggested as possibly between Greece and the Caspian Sea.

CLINTON, MD.

EXPLANATION OF PLATES XLII–XLIV

PLATE XLII

FIG. 1.—Young seedling: *R*, primary root; *Cot*, cotyledons; *Ep*, epicotyl; natural size.

FIG. 2.—Older seedling; natural size.

FIG. 3.—Part of same, showing shoots (*S*) in axils of cotyledons; natural size.

FIG. 4.—Floral shoot; natural size.

FIG. 5.—Flower seen from below; natural size.

FIG. 6.—Pod; natural size.

FIG. 7.—Same in longitudinal section; natural size.

FIG. 8.—Glandular hair; ×480.

PLATE XLIII

FIG. 9.—Cross-section of young root: *Ep*, epidermis; *C*, cortex; *End*, endodermis; *St*, stereome; *L*, leptome; *Camb*, cambium; ×112.

FIG. 10.—Part of same root: *P*, pericambium; other letters as given; ×744.

FIG. 11.—Cross-section of old root: *Co*, cork; *M*, medullary ray; *PH*, protohadrome; *P*, pith; ×90.

FIG. 12.—Part of same root; ×744.

FIG. 13.—Cross-section of leaf: *Ep*, ventral; *Ep+*, dorsal epidermis; *P*, palisade tissue; *P+*, pneumatic tissue; ×480.

PLATE XLIV

FIG. 14.—Part of root: letters as in fig. 11; *V*, vessels; ×744.

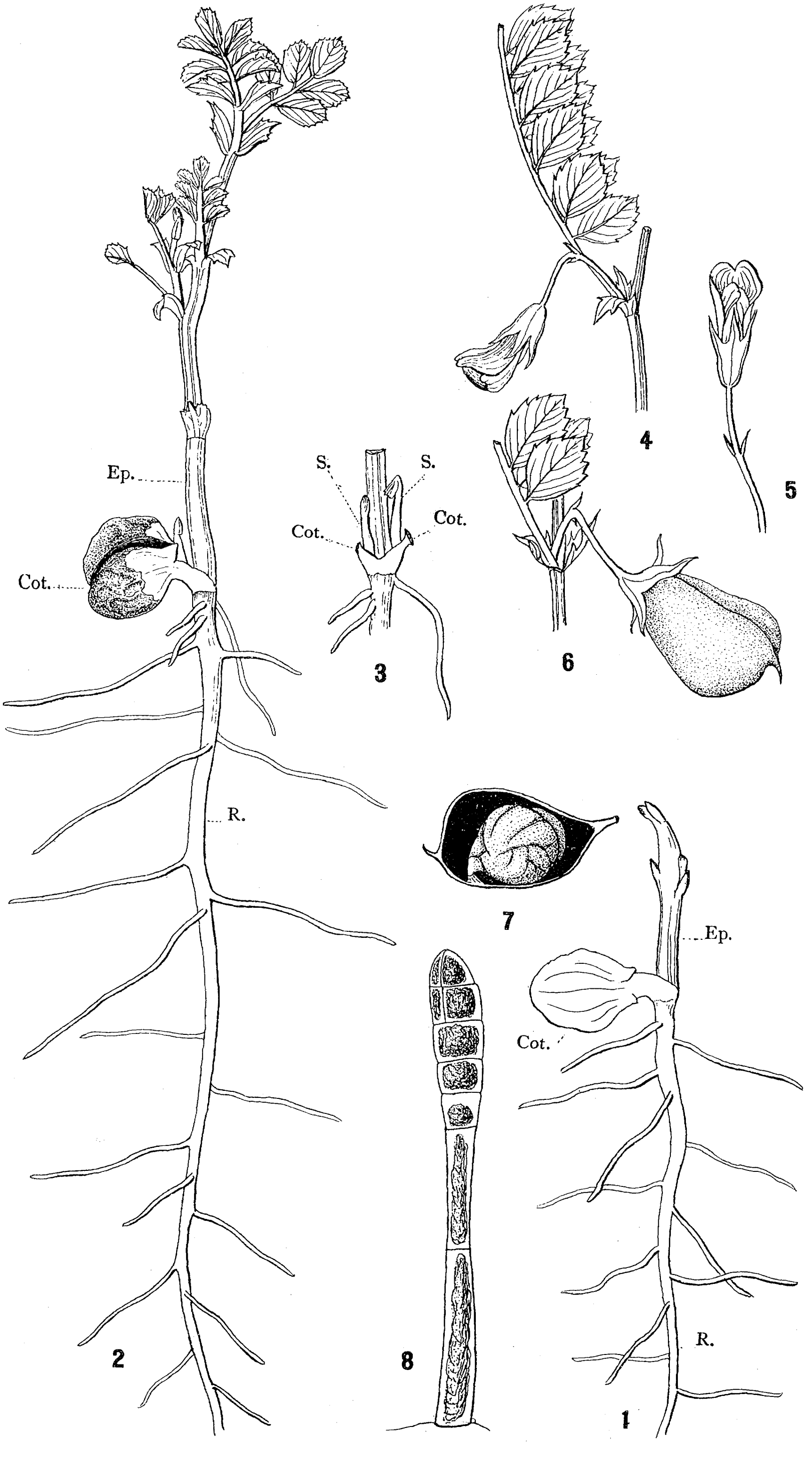
FIG. 15.—Cross-section of stem; ×480.

FIG. 16.—Part of same: *L*, leptome above interfascicular cambium (*Camb*); ×744.

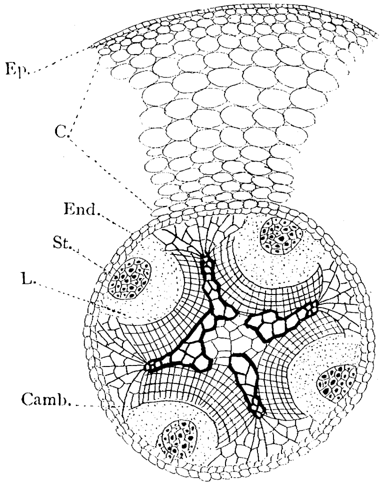
FIG. 17.—Part of same: *Coll*, collenchyma; ×480.

FIG. 18.—Part of same: all tissues of secondary formation; ×480.

FIG. 19.—Stoma of leaf; ×480.



HOLM on CICER



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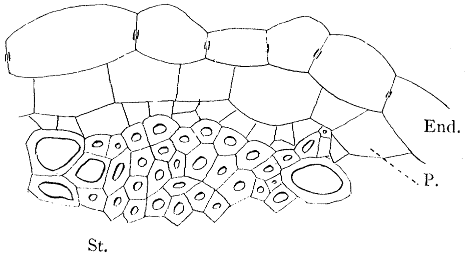

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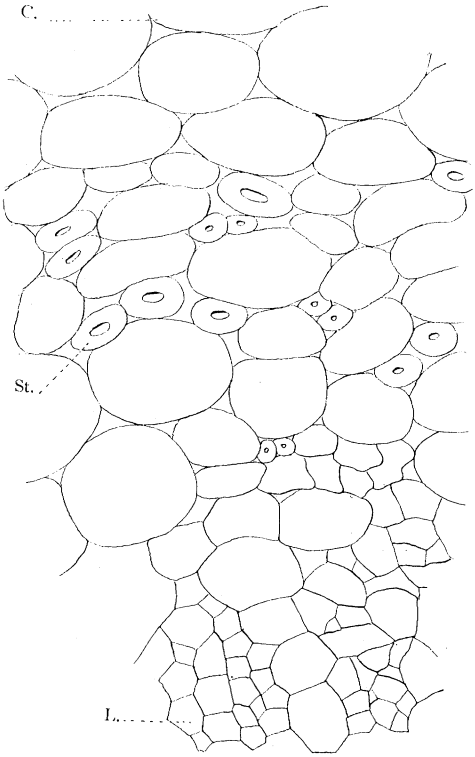

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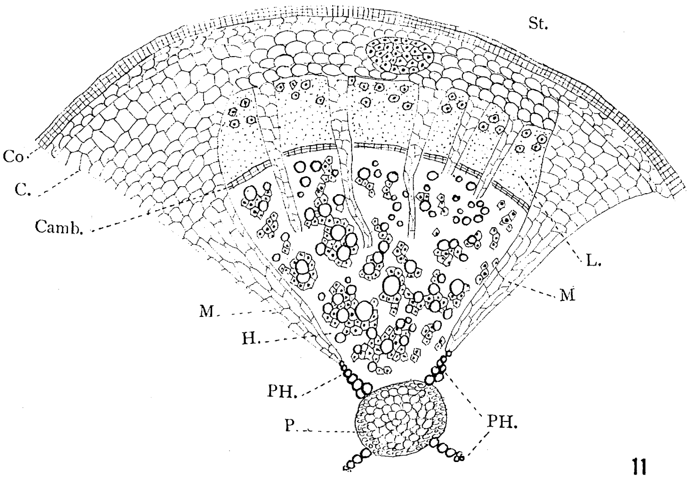

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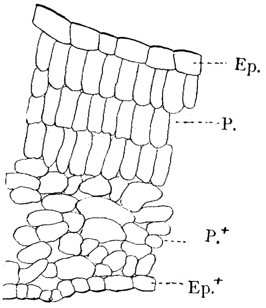

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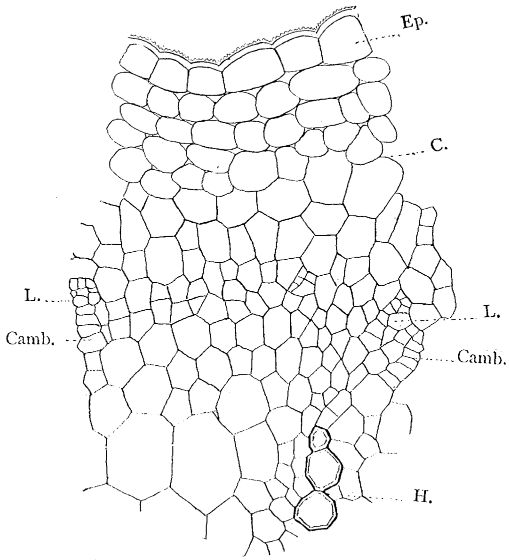

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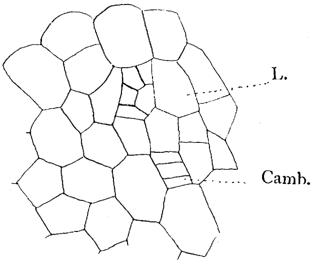

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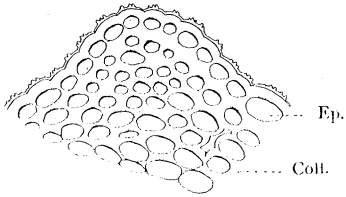

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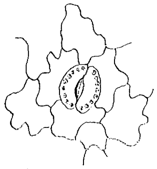

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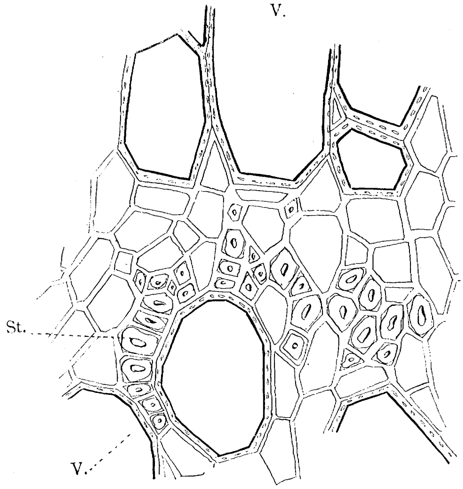

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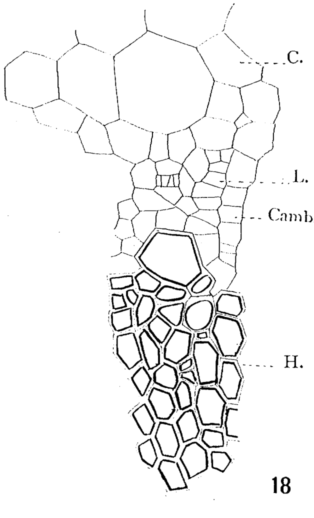

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